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THE HAWAIIAN MONK SEAL: POPULATION STATUS AND CURRENT RESEARCH ACTIVITIES

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CONTENTS

	Page
Introduction	1
Population Status and Current Research Activities	2
Population Status	2
Births	2
Beach Counts	3
Total Population Size	4
Survival	4
Island-Specific Observations and Activities	5
Kure Atoll	5
Pearl and Hermes Reef	6
Lisianski Island	7
Laysan Island	7
French Frigate Shoals	8
Recommendations	8
References	9

INTRODUCTION

The Hawaiian monk seal, *Monachus schauinslandi*, was classified as endangered under provisions of the Endangered Species Act (ESA) in 1976, following approximately a 50% reduction in beach counts of seals over a 20-year period (Johnson, DeLong, Fiscus, and Kenyon 1982). Censuses of seals on the beaches of the Northwestern Hawaiian Islands were conducted primarily by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Mammal Laboratory (NMML) of the National Marine Fisheries Service (NMFS) until 1980. Responsibility for research on the Hawaiian monk seal was transferred from the NMML to the Southwest Fisheries Center Honolulu Laboratory (SWFC) in 1980. Concurrent with identification of the SWFC as the center for monk seal research, the NMFS also appointed a Hawaiian Monk Seal Recovery Team as provided for by the ESA. The Recovery Team's primary charge was the development of a recovery plan for the species. The completed "Recovery plan for the Hawaiian monk seal, *Monachus schauinslandi*" (Gilmartin 1983) was approved by the Regional Director of the NMFS Southwest Region in April 1983.

The recovery plan contains an introductory section which gives the status of the species, known population limiting factors, and a summary of conservation efforts up to that time. The main body of the plan is divided into several categories for major research and other activities:

(1) Identification and mitigation of natural factors causing or contributing to decreased survival and productivity.

(2) Identification of habitat requirements and areas of special biological importance.

(3) Monitoring monk seal populations.

(4) Documentation of the effects of human disturbance.

(5) Implementation of listed management actions.

(6) Development of educational programs.

The many research and recovery activities within these categories were assigned priorities and agency responsibilities. The SWFC Hawaiian monk seal research and recovery program has been directed primarily at sections (1) through (4), but has also contributed information as requested for management decisions and educational programs (sections (5) and (6)). Certain priority research and recovery activities were identified very early in the Recovery Team's discussions, and as funding permitted, some of these activities were incorporated into the SWFC monk seal program beginning in 1981.

This report summarizes the present population status of the Hawaiian monk seal, describes research and recovery activities currently in progress, and makes recommendations for the continuing effort to recover this

species. The research and recovery activities conducted by the SWFC have received support in various forms in addition to its congressionally appropriated funds. This support has come from the Marine Mammal Commission, Hawaiian Islands National Wildlife Refuge (USFWS), U.S. Coast Guard, Center for Environmental Education, Marine Mammal Fund, Hawaiian Monk Seal Recovery Team, workshop participants, Makai Animal Clinic, Sea Life Park, Sea World Inc., Waikiki Aquarium, and numerous individual volunteers who have participated in the fieldwork and assisted in the care of captive seals.

POPULATION STATUS AND CURRENT RESEARCH ACTIVITIES

Research and recovery activities for the Hawaiian monk seal population are carried out through annual field expeditions to the major breeding islands. Duration of the field camps ranges from a few weeks to as long as 9 months, depending on the specific objectives of the work at each location. The primary objectives of the field camps are to (1) perform beach counts of seals to enable changes in the size and composition of the population to be detected; (2) double flipper tag all weaned pups; (3) resight as many individually identifiable (from tags and scar patterns) seals as possible to permit estimation of growth rates, survival rates, movement patterns, age at sexual maturity, and reproductive patterns; (4) observe the population and document any incidents that might negatively affect seal survival; (5) perform necropsies; (6) destroy fishing net and line fragments and other objects on the beaches that may entangle seals; and (7) free any observed entangled seals. The data collected in this monitoring program provide two pieces of information critical to the Hawaiian monk seal recovery task: Specific problems are identified, and the effects of experimental recovery activities are assessed.

Population Status

Monitoring the status of the monk seal population requires a variety of data, including number of pups born, number of seals hauled out (beach count), estimated number of seals, and survival rate. Using these categories, this section gives some background on the research methodology used to obtain these data and provides an overview of the monk seal population status.

Births

The number of Hawaiian monk seal pups born at the primary breeding islands of Kure Atoll, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals have been enumerated each year beginning in 1983 (Table 1). Data on births in 1977-82 are available from only some locations (Table 1) and before then as infrequent pup counts in scattered years back to the late 1950's. Although the data are limited, these pup counts represent the best means available to compare the present population with the populations of the 1950's through 1970's, because pup counts are less affected by varying methods, observers, seasons, and time of day than are counts of older seals.

Combined births from the primary breeding islands indicate an overall increase in pups born in recent years, from 163 in 1983 to 204 in 1987 (Table 1). Although this recent increase in total births is encouraging, two islands (Laysan and Lisianski) still have depleted populations which have yet to show any recovery response in the number of pups born. The number of births at Laysan Island has not changed appreciably from those reported since 1978, the year after a mass die-off of seals at that island (Gilmartin et al. 1980; Johnson and Johnson 1981). Lisianski Island, which has only been monitored since 1980, shows a continuing low number of observed pups. Since 1984, the SWFC program resources have been sufficient for only brief field camps at this location, so some pups may have been missed. However, a substantial undercount is unlikely because several brief visits were made during the breeding seasons.

A sharp increase in the number of births occurred in 1987 at Kure Atoll (Table 1), which had suffered a long decline from around 30 pups/year in the late 1950's and mid-1960's (Rice 1960; Wirtz 1968), to about 10 pups/year in the late 1970's, and finally to a low of a single pup born in 1986. The reasons for these changes are fairly well understood and are discussed below. Two other primary breeding populations with increasing numbers of pups born in the last few years are Pearl and Hermes Reef and French Frigate Shoals. Births at Pearl and Hermes Reef have doubled since 1983, from 11 to 22. French Frigate Shoals, where most monk seal births occur, had an increase in 1987, although whether this is a trend or merely a singularly high year is not apparent at this time.

The number of births recorded at Nihoa, Necker, and Midway Islands (Table 1) are a minimum. These small populations are observed infrequently, and the total number of births for all three locations combined probably does not exceed six per year.

Beach Counts

Uniform techniques for counting and sizing monk seals were finalized in 1983 and since then have been used at all the major breeding islands. These standardized techniques provide the best means for monitoring changes in the overall size and composition of the monk seal population. Because the number of seals hauled out may vary considerably from day to day, it is necessary to make repeated counts and compute an average to obtain a reliable statistic.

Mean beach counts for 1983, 1985, and 1987 at the five major pupping locations, plus Necker Island, are compared in Table 2. The overall total of mean counts has increased from 474 in 1983 to 586 in 1987. This trend is consistent with the increased number of births between 1983 and 1987.

The mean beach counts at Kure Atoll and French Frigate Shoals have increased slightly since 1983. Mean counts at Necker Island also increased; however, only single counts were made in 1985 and 1987 so not much weight can be put on its apparent increase. Laysan Island counts have shown a consistent and large increase. The factors behind this increase are not

well understood, but it is *not* an artifact of low number of counts nor of variable time periods among years. Lisianski Island had a slight decrease from 1983 to 1985 and then a large increase in 1987. This is, as discussed below, at least partly an artifact of the time of year (August) counts were made in 1987. The 1987 counts at Pearl and Hermes Reef were also made during August but did not show the expected increase. This decline in the 1987 count is therefore worrisome, especially since the Pearl and Hermes Reef population was expected to grow.

Total Population Size

Individual bleach marking of seals at Lisianski Island in 1983 (Johanos and Kam 1986) enabled the determination of correction factors for precise extrapolation of beach count data to population size and composition. The estimated number of seals of each size and sex class for 1987 (Table 3) was calculated from the mean beach count divided by the mean haul-out fraction of that size and sex class as described in Gerrodette (1985).

The 1987 estimates are complicated by the fact that at two locations, Pearl and Hermes Reef and Lisianski Island, the 1987 field camps were short (10 and 20 days, respectively) and their time periods (after 7 August) did not coincide with the 1983 camp (27 April-7 August) from which the haul-out fractions were computed. Therefore, the estimates in Table 3 for these locations assume that the haul-out fractions during late August are the same as earlier in summer. This is known to be false for adult males and perhaps for other size and sex classes as well: The haul-out fraction is higher for adult males in August when their annual molt begins, because they remain on the beach almost continuously during molting. Thus, the estimated numbers of adult males at Pearl and Hermes Reef and Lisianski Island for 1987 (Table 3) are too high. Ideally, the counts should be "seasonally adjusted," but since we lack the appropriate data from this time period to compute an adjustment factor, the nonseasonally adjusted figures are presented.

Keeping these limitations in mind, the 1987 nonpup population at the five major breeding locations plus Necker Island is estimated to be 1,516 seals (Table 3). Including pups (Table 1), the total population estimate at these locations is 1,718 seals. The number of monk seals at Nihoa and Midway, locations at which data are insufficient to include in Tables 2 or 3, is small and would not change the total significantly. The estimated total number of seals in 1987 (1,718) is about 15% higher than the total number estimated similarly in 1983 (1,488, Gerrodette 1985).

Survival

Tagging of monk seal pups by SWFC began at Kure Atoll in 1981. An evaluation of the effects of flipper tagging weaned pups was conducted in 1982 at Lisianski Island (Henderson and Johanos in press). No important adverse effects were detected, and pup tagging was expanded to all primary

breeding islands by 1984. Annual tag resighting efforts at these islands have been sufficient since then to resight all or nearly all surviving tagged seals. This tag and resighting program has yielded data that allow calculation of survival rates for juvenile seals (Gilmartin et al. 1987). The overall annual survival rate for young monk seals to age 4 was 88.7% for males and 90.8% for females, but this difference was not significant. Juvenile survival rates did not differ among islands or cohorts, but did differ by age. Median annual survival rates were 84.0% from birth to age 1 and 95.7% after age 1. Approximately 70% of the Hawaiian monk seals born survived to age 4. These findings show very high survival of young seals at this time and indicate that survival of pups and juveniles is not an impediment to recovery of the monk seal population. Because tagged seals are now reaching reproductive age, adult survival and reproductive rates will be available in the future if population monitoring is continued.

Island-Specific Observations and Activities

In addition to the general population monitoring work, certain other research and recovery activities are conducted at the major breeding sites. Highlights of these activities are presented below for each of the main populations.

Kure Atoll

The U.S. Coast Guard occupation of Green Island at Kure Atoll in 1961 and the subsequent human disturbance of monk seals on the beaches is believed to be the cause of changes in distribution of seals within the atoll and poor recruitment over two decades (Kenyon 1972). This in turn led to a gradual reduction in the number of seals and number of births. A low point was reached in 1986 when a single pup was born. Low pup survival was arrested in 1981 with initiation of the SWFC Head Start Project, in which female pups born at Kure Atoll were collected after weaning and placed in a large protective enclosure for their first summer. This action has continued annually since then and, along with U.S. Coast Guard procedural changes aimed at reducing seal disturbance (from that of the 1960's and early 1970's), has resulted in very high juvenile survival (Gilmartin et al. 1987). During the 1970's and through 1981, juvenile seals were only occasionally seen on the beaches at Kure Atoll. Now a high proportion of the population consists of immature seals (Gilmartin and Gerrodette 1986; Reddy and Griffith 1988).

The drastic decline in number of births at Kure Atoll caused concern that even the Head Start Project would be insufficient to reverse the downward trend in the number of seals. Therefore, another recovery action was initiated at Kure Atoll in 1984. Small, prematurely weaned female pups, which had a low probability of survival if left in the wild, were collected at French Frigate Shoals, "fattened" in Honolulu over a period of 7-9 months, and then released at Kure Atoll as yearlings (Gilmartin and Gerrodette 1986). These relocated seals have had a high survival rate and a low emigration rate. As of 1987, the Head Start Project and rehabilitation

effort have processed 16 and 8 female seals, respectively, all of which were released at Kure Atoll. Of these 24 female seals, 22 were alive at Kure Atoll in 1987, 1 had emigrated to another atoll, and 1 had died.

As a result of these attempts to increase the number and survival rate of young female seals at Kure Atoll, there is a high ratio of females in the immature portion of the Kure Atoll population. At present, the adult sex ratio is still biased toward males, but it should become equal within a few years and then move to favor females, if adult female survival remains high.

Based on several assumptions--female survival at Kure Atoll will remain very high, the age of first birth is 7 years, the adult female reproductive rate and pup survival rate will be comparable to other locations, and an average of three rehabilitated female yearlings will be added to the population each year through 1991--a female population projection developed for Kure Atoll showed that the number of female seals there could double between 1986 and 1991 and triple by the end of the century (Gilmartin and Gerrodette 1986). Since this projection was made, seals have been observed to give birth at age 6 at Kure Atoll and as early as age 5 at Laysan Island. This earlier age at first reproduction makes the above population projection slightly conservative; however, the most critical assumption for the accuracy of the projection is the high survival rate. Program resources permitting, these very successful recovery activities at Kure Atoll will be continued at least through 1991.

Pearl and Hermes Reef

Like the other monk seal populations at the far western end of the Hawaiian Archipelago, this population has been severely depleted. By 1978, beach counts had dropped more than 90% since the late 1950's (Johnson, DeLong, Fiscus, and Kenyon 1982). The cause of this decline at Pearl and Hermes Reef is uncertain. Only occasional beach count data are available for the 25 years prior to 1983.

Investigating this population for the first time with an extended presence at the atoll in 1983, the SWFC found the expected low beach counts of seals, but the animals appeared large and healthy, the expected number of females gave birth, the sex ratios within the age groups were nearly equal, adult male aggression was low, and no major injuries or fresh wounds were observed during a 3-month camp. These observations suggested the population should be growing or at least beginning to grow. To a large extent this prediction has been upheld. The number of births has doubled since 1983 (Table 1), and the mean beach count rose significantly between 1983 and 1985 (Table 2). However, the mean beach count declined in 1987. At present, the reasons for the decline are not understood; greater field effort at this location is required. With the recent high juvenile survival (Gilmartin et al. 1987) and apparent absence of injurious adult male aggressive behavior toward females, this population should increase, at least for the near future. Thirty years ago, the atoll did support a monk seal population several times larger than the present size.

Because of the low rate of wounding from aggressive adult males, Pearl and Hermes Reef is the best control location for the study of "mobbing" behavior at Laysan Island (see below).

Lisianski Island

By the mid-1970's when the Hawaiian monk seal was listed as "endangered" under the ESA, the Lisianski Island beach counts of seals had dropped to about 40% of the counts in the 1950's (Johnson, DeLong, Fiscus, and Kenyon 1982). The NMFS biologists observed this population for about 5 weeks in 1980 and counted at least 22 pups. Injuries and scars from mobbings were apparent in the population. The population assessment research of 1982-83 showed an adult sex ratio of more than two males per female, and mobbing incidents were observed (Stone 1984; Johanos and Kam 1986).

From 1983 to 1987, the number of known births at Lisianski Island has averaged 19 pups with no indication of an upward or downward trend (Table 1). The estimated number of seals in all other age and sex classes except adult males declined substantially during this time period (Table 3, compared with Table 3 in Gerrodette (1985)). The estimated number of adult males increased dramatically. However, because the 1987 data were from a different month, it is difficult to interpret the significance of these differences. The data require seasonal correction factors which are not available at this time. The Lisianski Island monk seal population needs more intensive study than has been possible in recent years. Despite the high immature survivorship, the number of adult females remains low, probably because of mobbing-associated mortality, but only more field effort can confirm this.

Laysan Island

The population change at Laysan Island between the late 1950's and the late 1970's was similar to Lisianski Island, a reduction in beach counts to approximately 40% of the former level. The Laysan Island population has been monitored closely since 1977. The first mobbing incident observed was here in 1978 (Johnson and Johnson 1981), and in that same year, young and old seals experienced unusually high mortality, believed due to ciguatoxin in the food fish (Gilmartin et al. 1980; Johnson and Johnson 1981).

Total beach counts of monk seals at Laysan Island are increasing (Table 2), but the number of births has not followed this trend (Table 1). The estimated 1987 monk seal population at Laysan Island (Table 3) has increased in all age and sex classes compared to 1983 (Gerrodette 1985), but the increase is particularly evident in the immature age classes. Survival of immature seals at Laysan Island is high (Gilmartin et al. 1987). With a young population and about 60% of the immature seals being female, the number of births should begin to increase.

However, aggressive male mobbings continue to be documented annually at Laysan Island. Current studies are attempting to determine the effect of the resultant female mortality on recovery potential. In 1987, a

research plan was developed to guide the investigation into this problem (Gilmartin and Alcorn 1987). Potential corrective actions are being developed and will be proposed for implementation if population growth here appears to be constrained by the mortality associated with this behavior.

French Frigate Shoals

The monk seal population at French Frigate Shoals has not changed much in recent years. Both the mean beach counts (Table 2) and the estimated number of seals (Table 3) have increased but slightly between 1983 and 1987. The number of births at French Frigate Shoals remained more or less constant at around 100 pups from 1980 to 1986, then increased in 1987, but this increase may be simply part of year-to-year variability. Weaned pup tagging was initiated at French Frigate Shoals in 1984, and this work includes collection of length and girth measurements. Weaned pups are significantly smaller at French Frigate Shoals than at other locations (unpubl. data), perhaps indicating that the population is near its carrying capacity. Cooperative research--with the University of Hawaii into the diving behavior and energetic expenditure of free-ranging monk seals and with the Smithsonian Institution into mother-pup behavior--is currently under way to test this hypothesis further.

RECOMMENDATIONS

To further our knowledge of monk seals and aid in their recovery, certain current activities should be continued and other new ones initiated. The sequence of recommendations below does not represent order of priority.

(1) Continue pup tagging and population monitoring programs. Expand the effort to fully assess and monitor population status at Lisianski Island and Pearl and Hermes Reef.

(2) Continue research on the mobbing problem at Laysan Island as outlined in Gilmartin and Alcorn (1987). Expand this research and appropriate recovery activity to Lisianski Island, if determined necessary.

(3) Continue through 1991, at least, the Head Start Project for Kure Atoll female pups and the rehabilitation work using French Frigate Shoals female pups.

(4) Introduce rehabilitated French Frigate Shoals yearling seals to Midway on an experimental basis to determine whether this program could contribute to rebuilding the Midway population as it has at Kure Atoll. Continue relocations to Midway if the survival rate and fidelity there are acceptable.

(5) Continue removal of beach debris capable of entangling seals.

(6) Develop information on foraging (diving) and beach use patterns for all primary breeding locations of Hawaiian monk seals in the Northwestern Hawaiian Islands

(7) Develop definition of "recovered" for the Hawaiian monk seal population.

(8) The recommendations in Gilmartin and Gerrodette (1986) should be implemented to enhance the recovery potential of the Kure Atoll monk seal population.

In summary, there are encouraging indications that the Hawaiian monk seal population is beginning to recover from its depleted status. Research conducted by the SWFC and others has been successful in identifying impediments to the recovery of the population, and recovery activities have been successful in overcoming some of them. Specific problems remain at certain locations. Continuing fieldwork is necessary to monitor the status of the population and to realize the full benefit of the tagging effort.

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Table 1.--Minimum number of Hawaiian monk seals born in the Northwestern Hawaiian Islands, 1977-87. Data for which no citations are given are on file at the Southwest Fisheries Center Honolulu Laboratory. Population totals are given only when births are known for at least the five major breeding sites.

	Seal births per year										
Location	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Nihoa Island										1	1
Necker Island							1	3		0	0
French Frigate Shoals				104[a]			98	106	96	108	121
Laysan Island	42[b]	29[b]	32[b]	33[b]	27	30	24	31	32	34	34
Lisianski Island				22		28	25	16	15	22	19
Pearl and Hermes Reef						11	17	19	18	22	
Midway									0	1	
Kure Atoll	10[c]	10[c]	10[d]	7[d]	10	5	4	6	5	1	6
Total							163	179	167	184	204

[a]Johnson, P. A., and B. W. Johnson (1984).
[b]Johnson, B. W., and P. A. Johnson (1984).
[c]Johnson, DeLong, Fiscus, and Kenyon (1982).
[d]Johnson, Ruehle, Kenyon, and Rauzon (1982).

Table 2.--Comparison of mean beach counts of Hawaiian monk seals in the Northwestern Hawaiian Islands, 1983, 1985, and 1987 (N = number of beach counts; $\bar{x}$ = mean beach count).

Location	1983 data			1985 data			1987 data		
	Date	N	$\bar{x}$	Date	N	$\bar{x}$	Date	N	$\bar{x}$
Necker Island	7/28-8/5	5	24.8	8/24	1	28.0	5/19	1	41.0
French Frigate Shoals	4/19-7/26	var.	234.8	5/23-8/23	9	266.7	4/19-7/14	9	260.6
Laysan Island	4/24-7/21	24	80.2	4/11-7/13	32	96.1	4/11-7/13	26	130.1
Lisianski Island	4/27-8/7	52	86.3	6/19-7/17	15	79.2	8/7-8/27	11	93.0
Pearl and Hermes Reef	5/30-7/14	5	26.6	6/23-7/11	12	44.7	8/16-8/26	11	36.2
Kure Atoll	4/22-6/28	31	21.4	4/2-9/21	60	22.5	3/29-9/20	62	24.9
Total			474.1			537.1			585.8

Table 3.--Preliminary population estimates of Hawaiian monk seals in the Northwestern Hawaiian Islands for 1987, based on extrapolations from beach counts.

Location	Adult		Subadult		Juvenile		Nonpup total	Grand total[a]
	Male	Female	Male	Female	Male	Female		
Necker Island	30	3	31	7	4	9	84	84
French Frigate Shoals	136	221	95	92	64	56	664	785
Laysan Island	117	53	38	58	35	43	344	378
Lisianski Island	189	28	19	12	8	10	266	285
Pearl and Hermes Reef	20	28	20	7	7	11	93	115
Kure Atoll	27	7	16	11	0	4	65	71
Total							1,516	1,718

[a]Includes known number of pups.